Year 1 Chapter 10: Forces and Motions (Horizontal Motions)

Q1.

A car of mass 1000 kg is towing a caravan of mass 750 kg along a straight horizontal road. The caravan is connected to the car by a tow-bar which is parallel to the direction of motion of the car and the caravan. The tow-bar is modelled as a light rod. The engine of the car provides a constant driving force of 3200 N. The resistances to the motion of the car and the caravan are modelled as constant forces of magnitude 800 newtons and R newtons respectively.

Given that the acceleration of the car and the caravan is 0.88 m s^{-2},

(a) show that $R = 860$,

(3)

(b) find the tension in the tow-bar.

(3)

(Total 6 marks)

Q2.

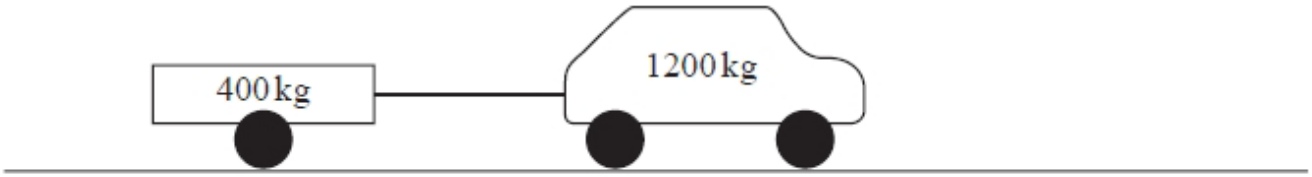

Figure 2

A car of mass 1200 kg is towing a trailer of mass 400 kg along a straight horizontal road using a tow rope, as shown in Figure 2.
The rope is horizontal and parallel to the direction of motion of the car.

- The resistance to motion of the car is modelled as a constant force of magnitude $2R$ newtons
- The resistance to motion of the trailer is modelled as a constant force of magnitude R newtons
- The rope is modelled as being light and inextensible
- The acceleration of the car is modelled as a m s^{-2}

The driving force of the engine of the car is 7400 N and the tension in the tow rope is 2400 N.

Using the model,
(a) find the value of a

(5)

In a refined model, the rope is modelled as having mass and the acceleration of the car is found to be a_1 m s^{-2}

(b) State how the value of a_1 compares with the value of a

(1)

(c) State one limitation of the model used for the resistance to motion of the car.

(1)

(Total for question = 7 marks)

Q3.
A car of mass 800 kg pulls a trailer of mass 200 kg along a straight horizontal road using a light towbar which is parallel to the road. The horizontal resistances to motion of the car and the trailer have magnitudes 400 N and 200 N respectively. The engine of the car produces a constant horizontal driving force on the car of magnitude 1200 N. Find

(a) the acceleration of the car and trailer,

(3)

(b) the magnitude of the tension in the towbar.

(3)

The car is moving along the road when the driver sees a hazard ahead. He reduces the force produced by the engine to zero and applies the brakes. The brakes produce a force on the car of magnitude F newtons and the car and trailer decelerate. Given that the resistances to motion are unchanged and the magnitude of the thrust in the towbar is 100 N,

(c) find the value of F.

(7)

(Total 13 marks)

Q4.

Figure 3

Two particles *P* and *Q*, of mass 0.3 kg and 0.5 kg respectively, are joined by a light horizontal rod. The system of the particles and the rod is at rest on a horizontal plane. At time $t = 0$, a constant force **F** of magnitude 4 N is applied to *Q* in the direction *PQ*, as shown in Figure 3. The system moves under the action of this force until $t = 6$ s. During the motion, the resistance to the motion of *P* has constant magnitude 1 N and the resistance to the motion of *Q* has constant magnitude 2 N.

Find

(a) the acceleration of the particles as the system moves under the action of **F**,

(3)

(b) the speed of the particles at $t = 6$ s,

(2)

(c) the tension in the rod as the system moves under the action of **F**.

(3)

At $t = 6$ s, **F** is removed and the system decelerates to rest. The resistances to motion are unchanged. Find

(d) the distance moved by *P* as the system decelerates,

(4)

(e) the thrust in the rod as the system decelerates.

(3)

(Total 15 marks)